WHPA

Salt Creek *E. coli* TMDL

Source Identification and Assessment Report

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1   Introduction

The objective of a Source Assessment is to characterize the type, magnitude, and location of potential sources of contaminant loading to a waterbody. The purpose of this interim report is to summarize Source Assessment activities for development of an *Escherichia coli (E. coli)* TMDL for the Salt Creek watershed. The report characterizes the known and suspected sources of *E. coli* loading to Salt Creek and presents estimates that will be used as a starting point for subsequent modeling activities.

The assessment of contributions from nonpoint sources was aided by use of the Bacterial Indicator Tool (herein referred to as "the Spreadsheet"). The Spreadsheet, distributed with BASINS 3.0, is a spreadsheet that estimates the bacteria contribution from multiple nonpoint sources [U.S. EPA, 2000]. The Spreadsheet was developed to provide a scientific basis for assigning values to source-loading parameters and has been used successfully for development of TMDLs across the country. The Spreadsheet was written specifically for TMDL development for fecal coliform, but was designed for adaptation for use with nutrients and other fecal indicators. WHPA adapted the Spreadsheet for use with *E. coli* by modifying the amount of bacteria in animal fecal matter from fecal coliform to *E. coli*. For example, the amount of fecal coliform in one gram of cow manure was changed to reflect the amount of the *E. coli* in one gram of cow manure. The Spreadsheet estimates loading rates from livestock, wildlife, and failing septics. In addition, the Spreadsheet estimates the accumulation rate and storage limits of waste buildup on four different land uses (cropland, forest, built-up, and pastureland). Output from the Spreadsheet was designed for use as input to dynamic water quality models such as the Hydrologic Simulation Program-Fortran (HSPF).

2   Point Sources

Point source pollution enters a water body at a known location. This type of pollution is regulated by state and federal agencies; permits are required for each pollution source. The concentration of one or more pollutants is monitored at the discharge point to ensure permit compliance. An example is effluent from factories, discharged via a ditch or pipe. In the Salt Creek watershed there are ten facilities that discharge sanitary wastewater into Salt Creek or one of its tributaries. Sanitary wastewater is wastewater originating from toilets, sinks, showers, and kitchen flows. Each of these facilities has the potential to contribute *E. coli*

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to the stream (Figure 1). The Indiana Department of Environmental Management (IDEM) issues National Pollution Discharge Elimination System (NPDES) permits to each facility and enforces compliance. The NPDES facilities collect the required number of samples and measure the concentration of each permitted parameter (Table 1). The limits are set at levels protective of both human health and aquatic life in waters that receive the discharge [IDEM, 2002].

Permitted facilities must compile and submit a Discharge Monitoring Report (DMR) to IDEM every month. DMR data from each of the permitted facilities was included in the Salt Creek Data Report approved by IDEM in January, 2003. The monitoring requirements are variable; some facilities are required to monitor *E. coli* concentrations while others are required to monitor fecal coliform and/or chlorine residuals (Table 1). The average annual loads to Salt Creek from the NPDES facilities are shown in Table 2. The *E. coli* load for facilities that do not monitor *E. coli*, but do monitor fecal coliform, were approximated using the estimation that 40% of the fecal coliform content in raw sewage is *E. coli* [Turner et al., 1997]. WHPA was unable to estimate the *E. coli* load for three small facilities that monitor only chlorine residual concentrations. Residual chlorine concentrations and *E. coli* concentrations are difficult to correlate due to variable dose and contact time in the disinfection process. Chlorine dosage and contact time are based on wastewater characteristics, such as concentrations of ammonia, biochemical oxygen demand, nitrated, pH, and total suspended solids [U.S. EPA, 1999].

In addition to daily effluent discharged to Salt Creek, facilities may also have 'bypass' discharges. Bypass discharges result when the facility capacity is exceeded due to wet weather or other circumstances. Unlike the regular discharges, bypass wastewater has had little or no treatment. The estimated *E. coli* load from bypass discharges is shown in Table 2. The estimated total annual *E. coli* load from NPDES facilities in the Salt Creek watershed, summing daily loads and average bypass loads, is 1.19×10^{16} CFU/year.

Combined sewer outfalls (CSO) are permitted through the NPDES. CSOs have the potential to contribute significant loads of fecal contamination during wet weather or storm events. Combined sewer systems consist of sanitary sewer pipes connected to stormwater sewer pipes. Normally this water is treated at the wastewater treatment plant (WWTP). However, significant rain events can overwhelm the capacity of combined sewers, causing an overflow. The overflow event discharges both stormwater and sewer water from an outfall into nearby streams. The overflow water contains high concentrations of *E. coli* and
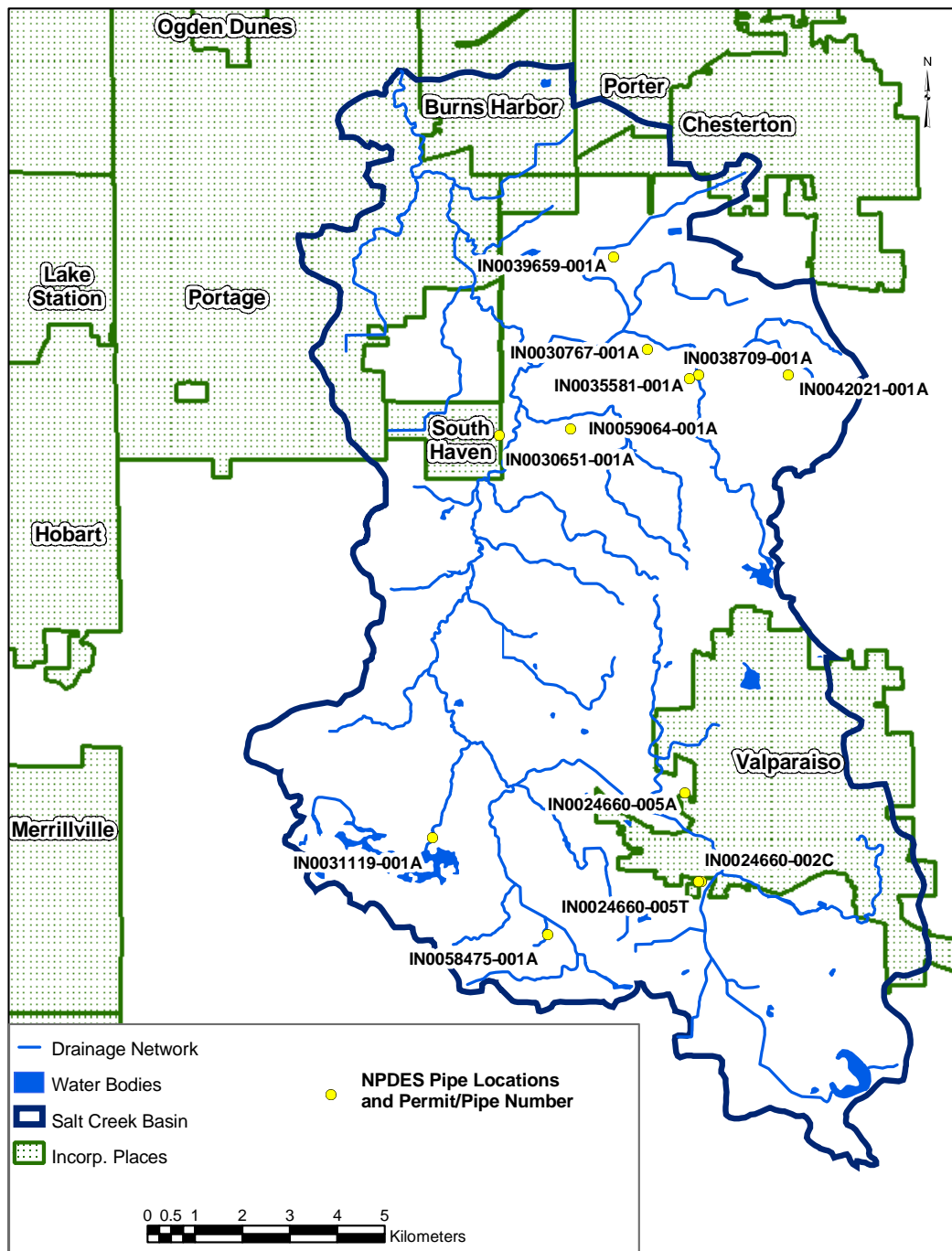
Figure 1: NPDES effluent-pipe locations in the Salt Creek watershed that are potential sources of *E. coli.*

Table 1: NPDES facilities in Salt Creek watershed that are potential sources of *E. coli* and their monitoring requirements.

Permit Number	Facility Classification	Facility Owner/Operator	CSO	E. coli	Fecal coliform	Chlorine Residuals	Ultraviolet Light
IN0024660	Major	Valparaiso Municipal STP	1	7/week	7/week	7/week	–
IN0030651	Major	South Haven Sewer Works	–	5/week	–	5/week	–
IN0030767	Minor	Liberty Elementary and Middle School	–	1/week	1/week*	2/week	–
IN0031119	Minor	Shorewood Forest Utilities	–	1/week	–	2/99 days**	5/week
IN0035581	Minor	Sands Mobile Home Park	–	–	–	2/week	–
IN0038709	Minor	Liberty Farm Mobile Home Park	–	–	–	5/week	–
IN0039659	Minor	Burns Harbor Estates	–	–	1/week	2/week	–
IN0042021	Minor	Elmwood Mobile Home Park	–	–	1/week	2/week	–
IN0058475	Minor	Nature Works Conservancy District	–	3/week	–	–	5/week
IN0059064	Minor	Mallard's Pointe Condominium	–	–	–	2/week	–

[Major, ≥ 1 MGD facility; Minor, ≤ 1 MGD facility; STP, ⇒ sewage treatment plant; '#'/week, number of sample measurements per week required by permit; *, parameter monitored from 1983-1998; **, parameter monitored from 1991-1996]

Table 2: Average flow and estimated annual *E. coli* loads to Salt Creek from NPDES facilities.

Permit Number	Data Period	Ave. Flow (MG/yr)	Ave. E. coli (CFU /100 mL)	Load from Effluent (CFU/yr)	Ave. Bypass 1994-2001 (no/yr)	Ave. Bypass Flow (MG/yr)	Load from Bypass* (CFU/yr)	Total Load (CFU/yr)
IN0024660	6/01-4/02	1,803	8	5.42×10^{11}	12	126	4.78×10^{15}	4.78×10^{15}
IN0030651	1/89-4/02	429	17	2.71×10^{11}	4	1.13	4.28×10^{13}	4.31×10^{13}
IN0030767	6/01-4/02	7	58	1.47×10^{10}	0.25	0.04	1.52×10^{12}	1.53×10^{12}
IN0031119	10/91-4/02	75	14	4.14×10^{10}	–	–	–	4.14×10^{10}
IN0035581	4/89-4/02	5	/	/	0.13	0.003	1.14×10^{11}	1.14×10^{11}
IN0038709	4/90-4/02	10	/	/	–	–	–	
IN0039659	4/89-4/02	18	122**	8.32×10^{10}	–	–	–	8.32×10^{10}
IN0042021	5/92-10/00	16	390**	2.29×10^{11}	0.13	188	7.13×10^{15}	7.13×10^{15}
IN0058475	9/96-6/01	15	19	1.10×10^{10}	–	–	–	1.10×10^{10}
IN0059064	6/99-4/02	4	/	/	–	–	–	
TOTAL				**1.19x**10^{12}			**1.20x**10^{16}	**1.20x**10^{16}

[*Assumes concentration in sewage of 1 x 10^{6} CFU/100mL [Turner et al., 1997]; **, E.coli data not available because facility measures fecal coliform only. Therefore, it was assumed that 40% of the fecal coliform counts consists of E. coli [Turner et al., 1997]; /, E. coli and/or fecal data not available because facility measures chlorine only; –, no bypasses reported; ave, average; yr, year; max., maximum; MG, million gallons; no., number; CFU, colony forming units.]

other pathogens.

Until 2001, the city of Valparaiso had three CSOs, but two have since been removed. The remaining CSO in the watershed is permitted to the Valparaiso Municipal Sewage Treatment Plant (Table 1). Unlike discharge reports for NPDES facilities, which have been recorded for decades, DMRs for CSOs have been collected only since October 2001. Consequently, the data record is relatively small. According to the DMRs, the Valparaiso CSO had 20 overflow events from October 2001 through December 2002.

The Interagency Task Force (ITF) collected flow and concentration data from the Valparaiso CSO during the recreational season of 1998. Results from that work are presented in the Salt Creek Data Report [WHPA, 2003a]. The ITF data were not used in the Source Assessment to calculate loads because the *E. coli* counts during sampled overflow events were not quantifiable (i.e. "too numerous to count") [WHPA, 2003a].

Table 3: Discharge and *E. coli* load information for the CSO in Valparaiso in 2002.

Overflow Date	Volume of Sanitary Sewer-water (MG)	Volume of Stormwater (MG)	Total Volume of Overflow (MG)	*E. coli* load* (CFU)
1/31/01	6.20	4.30	10.50	2.38×10^{14}
3/08/02	3.90	8.50	12.40	1.51×10^{14}
3/09/02	4.00	16.30	20.30	1.56×10^{14}
4/02/02	0.50	1.45	1.95	2.04×10^{13}
4/08/02	0.70	6.69	7.39	3.00×10^{13}
4/09/02	2.70	4.47	7.17	1.04×10^{14}
4/21/02	1.00	1.54	2.54	3.79×10^{13}
4/27/02	0.20	0.75	0.95	9.58×10^{12}
4/28/02	0.75	0.26	1.01	2.85×10^{13}
5/09/02	0.67	3.00	3.67	2.64×10^{13}
5/11/02	2.78	21.62	24.40	1.13×10^{14}
5/12/02	9.50	86.5	96.00	3.93×10^{14}
5/13/02	1.5	0.88	2.38	5.72×10^{13}
12/18/02	1.4	0	0.59	5.43×10^{13}
TOTAL				1.42×10^{15}

[*Assumes stormwater concentration of 1 x 10^4 CFU/100mL and sanitary sewer-water concentration of 1 x 10^6 CFU/100mL [Marsalek and Rochfort, 2002, Turner et al., 1997]; MG, million gallons; CFU, colony forming units.]

Data submitted on the DMRs was used to estimate *E. coli* loading to Salt Creek from the CSO. The daily flow into the WWTP was used to estimate the volume of sanitary sewage that was flowing during the overflow event. The *E. coli* load from sanitary sewage was calculated assuming a concentration of 1 x 10^6 CFU/100 mL [Turner et al., 1997]. The sanitary sewage volume was subtracted from the total overflow volume to calculate the volume of stormwater, which is assumed to have an *E. coli* concentration of 1 x 10^4 [Marsalek and Rochfort, 2002]. Table 3 shows the estimated 2002 *E. coli* load to Salt Creek due to the CSO.

3 Nonpoint Sources

Nonpoint source (NPS) pollution comes from diffuse sources that cannot be identified as entering the water body at a single location. These sources generally involve land activities that contribute pollution to streams during wet weather events. Rain or snow-melt moves over and through the ground where pollutants have accumulated, transports the contaminants, and deposits them into nearby waterbodies. Bacterial NPS pollution is generated by both human and non-human (animal) sources via land use activities. Typical non-point sources of *E. coli* include, but are not limited to:

- Manure application to cropland

- Livestock grazing on pastureland

- Livestock with direct access to streams

- Wildlife

- Urban land activities

- Leaking / failed septic systems

Parameters for each source described above were input into the Spreadsheet. The Spreadsheet allows the watershed to be divided into a maximum of ten subwatersheds. WHPA divided Salt Creek into five subwatersheds (Figure 2). The subwatersheds were chosen based on the natural topographic divisions within the watershed. Typically the divisions were made at the confluence of major tributaries to Salt Creek. The subwatersheds were delineated with a Geographic Information System (GIS) that allowed for use of best professional judgment. The subwatershed data was then input into the Spreadsheet. The Spreadsheet estimates the monthly accumulation rate and storage limit of bacteria for four land use categories: built-up, cropland, forest, and pastureland. The accumulation rates and storage values are determined for each subwatershed / land use combination. The accumulation rate (ACQOP) and storage limit (SQOLIM) can be used as input for the dynamic water-quality model HSPF as MON-ACCUM (accumulation rate) and MON-SQOLIM (storage limit). The effects of failed septics and cattle with direct access to streams is calculated as a constant monthly load for each subwatershed. The estimated loads can be used as input for modeling. Table 4 summarizes the output sheets in the Spreadsheet. Loading estimates and all output from the Spreadsheet is presented in the Appendix.
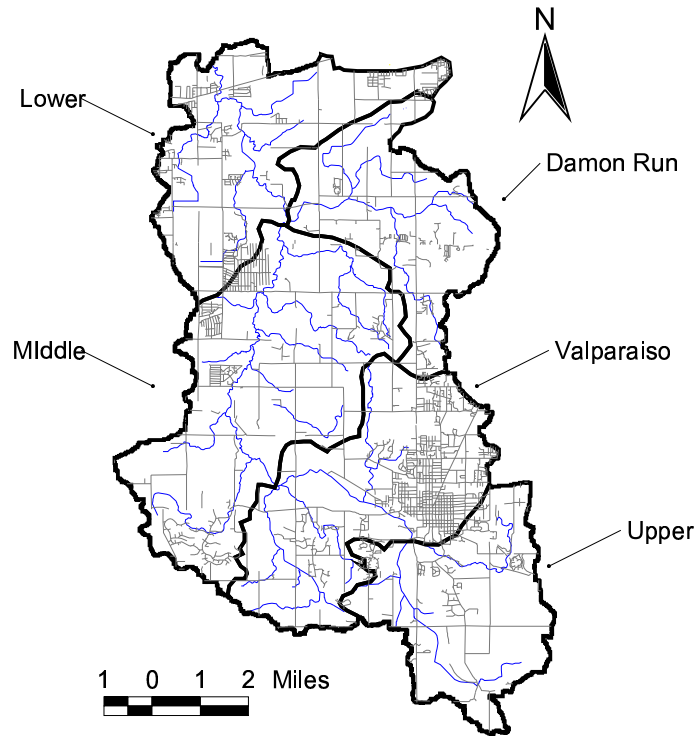
Figure 2: The five Salt Creek subwatersheds; Upper, Valparaiso, Middle, Damon, and Lower.

3.1 Subwatershed Landuse

The Salt Creek watershed was divided into five subwatersheds and four land uses (Figure 2 & Table 5). The geographic distribution of land uses in the watershed were provided by the Indiana Land Cover Dataset [USGS, 2000]. The loading for *each* land use is modeled to reflect the practices that occur in that area. The Spreadsheet allows for build-up and wash-off of *E. coli* in conjunction with rain events for each land use type.

3.2 Livestock

Manure from livestock is a potential source of *E. coli* to Salt Creek. The number of animals, the amount of manure produced by each animal, and the concentration of *E. coli* in the manure are used to calculate the impact of livestock on Salt Creek (Table 6 & 7). The *E.*

Table 4: Description of the output worksheets provided in the Bacterial Indicator Tool. Modified from [U.S. EPA, 2000].

Worksheet Name	Purpose
Cropland	Calculates monthly rate of accumulation and storage limit of *E. coli* on cropland from wildlife, and application of hog, cattle, and poultry manure.
Forest	Calculates monthly rate of accumulation and storage limit of *E. coli* on forestland from wildlife.
Built-up	Calculates monthly rate of accumulation and storage limit of *E. coli* on built-up land from literature values.
Pasture	Calculates monthly rate of accumulation and storage limit of *E. coli* on pastureland from wildlife, cattle, horse, sheep, and other grazing.
Cattle in Streams	Calculates the monthly loading and flow rate of *E. coli* contributed directly to the stream by beef cattle.
Septics	Calculates the monthly loading and flow rate of *E. coli* contributed by failing septics.
ACQOP & SQOLIM	Summarizes the monthly rate of accumulation and storage capacity for *E. coli* for the four land uses. Provides input parameters for HSPF (ACQOP/MON-ACCUM and SQOLIM/MON-SQOLIM)

coli concentrations in livestock feces are estimates by researchers who study *E. coli* extensively and have experience with the relevant species. The *E. coli* estimate for chickens was provided by Dr. Mike Jenkins of the Agricultural Research Service [Jenkins, 2003]. The *E. coli* concentration for horse manure was provided by Dr. Robert Atwill of the University of California-Davis [Atwill, 2003]. The *E. coli* concentration for cow manure was provided by a study performed by [Jordan and McEwen, 1997]. The *E. coli* concentration number for cow was also verified by Dr. Atwill and Dr. Jeffery Karns [Atwill, 2003, Karns, 2003]. Dr. John Patterson verified that all the livestock estimates for *E. coli* concentrations in fecal matter were reasonable [Patterson, 2003]. The quantity of manure produced from chickens, cows, horses, pigs, and sheep are values provided by the American Society of Agricultural Engineers (ASAE) in the Spreadsheet references [U.S. EPA, 2000]. The quantity for goats was estimated to be similar to the value provided for white-tailed deer [VADEQ, 2001].

The number and location of livestock was determined by a windshield survey of the watershed [WHPA, 2003b]. During the windshield survey observations were recorded as

Table 5: Land use information for the five subwatersheds in the Salt Creek watershed [USGS, 2000].

Subwatersheds	Built-up (%)	Cropland (%)	Forest (%)	Pasture (%)	Total Area (% of total)
Upper Salt Creek	15	29	27	29	16
Valparaiso	44	11	28	17	22
Middle Salt Creek	13	28	33	26	28
Damon Run	12	21	41	26	15
Lower Salt Creek	25	31	29	15	19
Entire Watershed	22	24	32	22	100

every road in the watershed was driven and the livestock were counted. The locations were marked with a Global Position System. The data were then overlaid on a watershed map and clipped to the watershed so as to not include observations outside of the watershed boundaries. Additional information about livestock and verification of the windshield survey data was provided from a meeting on February 6, 2003 with members of the Porter County Natural Resource Conservation Service (NRCS), the Porter County Farm Service Agency, and the Porter County Cooperative Extension Service (Table 7) [Ames et al., 2003]. Based on the survey and the subsequent meeting with local agricultural professionals, no chickens or swine were located within the watershed.

The total estimated production from livestock was calculated by multiplying the number of animals times the estimated amount of *E. coli* produced from each animal (Table 8).

3.3   Pastureland / Cropland

In the Salt Creek watershed most cattle and horse owners graze their livestock year round, but 'bed' their animals at night in a barn [Ames, 2003]. While grazing, livestock deposit fecal matter directly onto pastureland and often times directly into streams. Manure deposited onto pastureland is exposed to the environment for a period of time and is available for runoff during storm events. The manure from the barn is collected and applied to croplands. Because of this variation in source type, manure from livestock is treated as three separate sources in the Spreadsheet; originating from pasture grazing, direct input into streams, and manure applied to cropland.

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Table 6: Livestock sources of *E. coli* in Salt Creek watershed.

Animals	Estimated *E. coli* in fecal matter (CFU / gram feces)	Estimated amount of fecal matter (grams / day / animal)	Estimated Loading Rate of *E. coli* (CFU / day / animal)
Cattle, Beef[1,2,4,5]	10^6	2.1×10^4	2.1×10^{10}
Cattle, Dairy[1,2,4,5]	10^6	5.5×10^4	5.5×10^{10}
Chicken[1,3]	10^6	1.2×10^2	1.2×10^8
Goats[1]	10^6	7.7×10^2	7.7×10^8
Hogs[1]	10^6	5.0×10^3	5.0×10^9
Horses[1,2]	10^6	2.3×10^4	2.3×10^{10}
Sheep[1]	10^6	9.1×10^2	9.1×10^8

CFU = colony forming units; [1], E. coli concentration provided by [Patterson, 2003];[2], E. coli concentration provided by [Atwill, 2003];[3], E. coli concentration provided by [Jenkins, 2003]; [4], E. coli concentration provided by [Karns, 2003];[5], E. coli concentration provided by [Jordan and McEwen, 1997].

Table 7: Estimated number of livestock in the Salt Creek subwatersheds.

Subwatersheds	Cattle, Beef (number)	Cattle, Dairy (number)	Goats (number)	Horses (number)	Sheep (number)
Upper Salt Creek	65	0	3	4	0
Valparaiso	0	0	0	16	0
Middle Salt Creek	144	0	3	26	11
Damon Run	81	56	23	30	5
Lower Salt Creek	15	0	0	2	0
Total in Watershed	305	56	29	78	16

Table 8: The estimated *E. coli* production from livestock in the Salt Creek subwatersheds.

Subwatersheds	Cattle, Beef (CFU/year)	Cattle, Dairy (CFU/year)	Goats (CFU/year)	Horses (CFU/year)	Sheep (CFU/year)
Upper Salt Creek	5.0×10^{14}	0	8.5×10^{11}	3.3×10^{13}	0
Valparaiso	0	0	0	1.3×10^{14}	0
Middle Salt Creek	1.1×10^{15}	0	8.5×10^{11}	2.2×10^{14}	4.4×10^{12}
Damon Run	6.2×10^{14}	1.1×10^{15}	6.5×10^{12}	2.5×10^{14}	2.0×10^{12}
Lower Salt Creek	1.1×10^{14}	0	0	1.7×10^{13}	0
Total in Watershed	2.3×10^{15}	1.1×10^{15}	8.2×10^{12}	6.5×10^{14}	6.4×10^{12}

CFU = colony forming units

Land application of manure helps reduce or eliminate the need for commercial fertilizers. It can be applied in four different ways 1) surface broadcast followed by disking 2) broadcast without incorporation 3) injection under the surface, or 4) irrigation. In Porter County, Indiana, animal manure is generally applied with incorporation in the spring (April - May) and fall (October - November) [Ames, 2003, Sutton, 2003]. It is estimated that livestock farmers only collect and store manure from cattle and horse deposits in their barns where the animals bed at night [Ames, 2003]. It is assumed that livestock usually spend $\frac{1}{3}$ of a typical day indoors. Therefore, the amount of total manure from cattle and horses applied to land was estimated to be $\frac{1}{3}$ of the amount produced by each animal. This fraction of the total for horse and cattle manure is distributed over the four months manure is applied to fields. The Spreadsheet assumes that cattle manure is applied to cropland, horse manure is applied to pastureland, and no manure is applied to forest or built-up areas.

The manure that is not applied by the livestock owners is assumed to all be added directly to the pasture by the animals. The manure deposited directly by the animals onto pastureland ($\frac{2}{3}$ of total) is not incorporated, but remains a source for runoff events. This fraction of the total for horse and cattle manure is distributed over twelve months because the animals are allowed to graze throughout the year.

Access to streams allows livestock to input manure directly into the streams. During the meeting on February 6, 2003, the county agents indicated where livestock have stream access [Ames et al., 2003]. Based on these discussions, 31% of the total cattle in the watershed have access to a stream. It was estimated that these cattle would only spend 10% of

grazing time in the stream. It was assumed that most horse owners do not allow their horses access for fear of disease, so no access was input for horses [Ames et al., 2003]. Estimated monthly accumulation rates and storage limits for cropland and pasture are presented in the Appendix, Table 1A and Table 2A. Estimated loading rates from cattle with direct access to streams are presented in Table 3A.

3.4   Wildlife

Wildlife also contributes to *E. coli* in streams through runoff of fecal matter. The wildlife assumed to be major contributors in the watershed are coyote, deer, duck, geese, opossum, raccoon, and turkey. The Indiana Department of Natural Resources surveys wildlife to establish population trends for specific species but does not survey to determine population numbers [Byer, 2003]. Therefore, other resources determined the densities of the wildlife. The deer density was estimated by the Quality Deer Management Association (Table 9) [QDMA, 2002]. The wildlife densities for coyote and raccoon were estimated by officials at the NRCS (Table 9) [Ames et al., 2003]. The estimates for turkey and opossum were taken from the literature [Schwartz and Schwartz, 1981]. The density of geese was estimated using Indiana state population numbers for geese, historic population data, and the WHPA windshield survey [WHPA, 2003b, U.S. Geological Survey, 1999, IDNR, 2002]. The density of ducks was estimated from the U.S. Fish and Wildlife Service Adaptive Harvest Management [U.S. Fish and Wildlife Service, 2002]. The wildlife densities were assumed to be similar in all land uses, except built-up. The Spreadsheet assumes no wildlife in the built-up areas of the watershed.

The *E. coli* load in fecal matter for wildlife was based on the work of Dr. Rob Atwill, researcher of *E. coli* and wildlife studies at the University of California - Davis [Atwill, 2003]. The estimated amount of fecal matter produced per animal for deer, geese, and raccoon were provided from an EPA approved TMDL for fecal coliform in Virginia [VADEQ, 2001]. The amount of fecal matter produced by turkey and duck was provided by the ASAE in the Spreadsheet references [U.S. EPA, 2000]. Opossum values are assumed to be similar to that of a small dog. This value was provided by ASAE [U.S. EPA, 2000]. The amount of fecal matter from coyote is assumed to be similar to a large dog [VADEQ, 2001, WOW, 2003].

The numbers of each type of animal in the land uses were calculated by multiplying their assumed densities with the area of each land use type (Tables 5 & 10). The estimated amount of *E. coli* from wildlife each year was then calculated by multiplying the number

Table 9: Wildlife sources of *E. coli* in Salt Creek watershed.

Animals	Animals in watershed (animal / sq. mile)	*E. coli* content in fecal matter (CFU / gram feces)	Estimated amount of fecal matter (grams / day / animal)	Estimated amount of manure (CFU / day / animal)
Coyote	1	10^6	450	4.5×10^8
Deer	20	10^6	772	7.7×10^8
Duck	5	10^6	125	1.25×10^8
Geese	7	10^6	163	1.6×10^8
Opossum	130	10^6	227	2.3×10^8
Raccoon	80	10^6	450	4.5×10^8
Turkey	3	10^6	151	1.5×10^8

sq. = square; CFU = colony forming units

of each animal times the amount of manure produced by each (Tables 9 & 11). As Table 11 shows, waste from raccoon, opossum, and deer produce 97% of the total *E. coli* from wildlife in the watershed. Estimated monthly accumulation rates and storage limits for forestland in each subwatershed are presented in the Appendix, Table 4A.

3.5 Urban / Industrial Lands

Runoff from urban and industrial areas can potentially contribute bacteria to streams and rivers. The bacteria can come from such sources as pet feces, urban wildlife, sanitary sewer cross-connections, and deficient solid waste collection. To assess the impact of the urban runoff, the Spreadsheet divides the built-up areas into four sub-categories and calculates the loading rates for each of these divisions based on published accumulation rates [U.S. EPA, 2000]. Unfortunately, similar accumulation rates are not available for *E. coli,* so WHPA estimated loading rates for *E. coli* based on the published values for fecal coliform. This estimation assigns the entire built-up area one accumulation rate instead of different rates for each sub-category.

   E. coli is a subset of fecal coliform, meaning measurement of fecal coliform includes all measurement of *E. coli,* along with other pathogens. The amount of *E. coli* will be lower than the amount of fecal coliform in manure. Therefore, the low-end of the range for the

Table 10: The estimated number of wildlife in various land uses in the Salt Creek watershed.

Animals	Cropland (number)	Forest (number)	Pastureland (number)	Total (number)
Coyote	23	31	22	76
Deer	364	482	343	1,189
Duck	94	124	88	306
Geese	129	171	122	422
Opossum	2,347	3,108	2,211	7,667
Raccoon	1,467	1,942	1,382	4,791
Turkey	59	78	55	192

Table 11: The estimated *E. coli* load from wildlife in the Salt Creek watershed.

Animals	Cropland (CFU/year)	Forest (CFU/year)	Pastureland (CFU/year)	Total (CFU/year)	% of Total
Coyote	1.9×10^{12}	2.6×10^{12}	1.8×10^{12}	6.3×10^{12}	0.3
Deer	1.0×10^{14}	1.3×10^{14}	9.7×10^{13}	3.3×10^{14}	18
Duck	4.3×10^{12}	5.7×10^{12}	4×10^{12}	1.4×10^{13}	0.7
Geese	7.5×10^{12}	1×10^{13}	7.1×10^{12}	2.5×10^{13}	1
Opossum	2.0×10^{14}	2.6×10^{14}	1.9×10^{14}	6.5×10^{14}	36
Raccoon	2.4×10^{14}	3.2×10^{14}	2.3×10^{14}	7.9×10^{14}	43
Turkey	6.9×10^{12}	9.1×10^{12}	6.4×10^{12}	2.2×10^{13}	1

CFU = colony forming units

fecal coliform accumulation rates was used as an estimation for *E. coli*. The accumulation rates for fecal coliform range from $1.8 \times 10^8 - 2.1 \times 10^{10}$ count/acre/day [U.S. EPA, 2000]. The accumulation rate for *E. coli* in urban areas was designated as 1.8×10^8 count/acre/day. Estimated monthly accumulation rates and storage limits are presented in the Appendix, Table 5A.

3.6   Septic Systems

Failing septic systems also contribute pathogen loads to receiving waters. However, specific information regarding the location and nature of failed systems in the watershed is unknown. The distribution of failed septics in the watershed was estimated using available information [U.S. Census Bureau, 1999, NESC, 2001]. The technique used is described briefly in EPA's Protocol for Developing Pathogen TMDLs [U.S. EPA, 2001] and in more detail in results describing a similar application to nutrient loads [Nizeyimana et al., 1996]. The method uses information from the 1990 census and county level failure rates published by the National Small Flows Clearinghouse (NSFC). Porter County population and housing information was retrieved from the U.S. Census Bureau [U.S. Census Bureau, 1999]. Septic tank use is included in the housing information from the 1990 census. Unfortunately, the same information was not included in the 2000 census. Using data from 1990 may result in underestimating the impact from failing septics. The population of the county increased by about 20,000 people from 1990 to 2000. However, problems with failed or leaky septics are generally attributed to older homes. The underestimation may derive from the likelihood that some older septics failed in the 10 years that have passed since the NSFC survey.

Figure 3 shows the block group distribution of houses on septic in the watershed. The number of persons per household in each tract was estimated by dividing the number of persons in the tract by the number of houses in the tract. The number of persons on septic in each tract was then estimated by multiplying the estimated number of persons per household by the number of houses on septic in the tract (Figure 4). The population density on septic was then estimated by dividing the number of persons on septic in the tract by the tract area (Figure 5). The population density on septic was then used with GIS software to calculate the number of persons on septic in each of the five subwatersheds (Table 12).

Loads from failing septics in each subwatershed were calculated with the Spreadsheet. The number of persons on septic for each subwatershed was multiplied by the septic failure rate for the area. The septic failure rate was estimated from data collected by the NSFC.
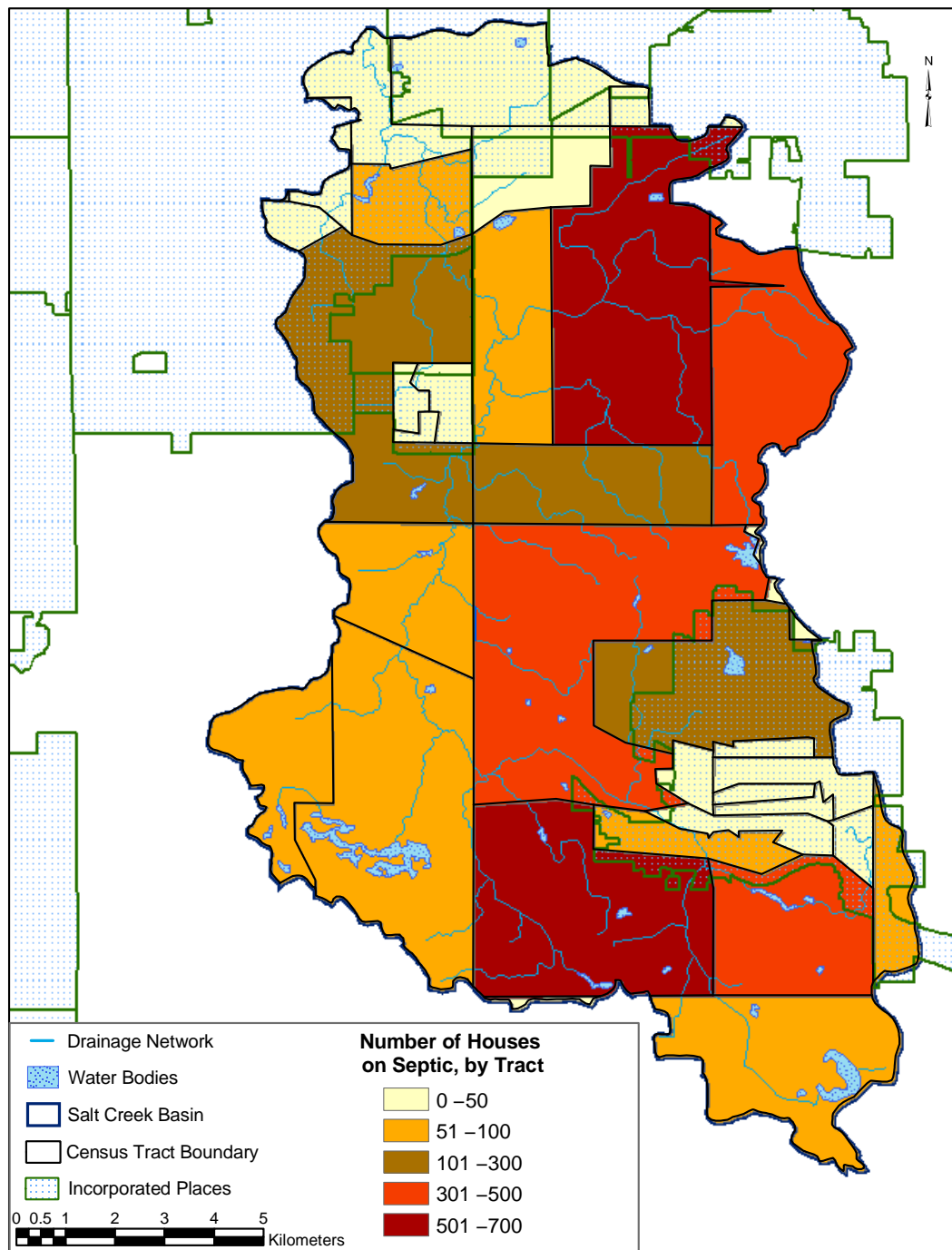
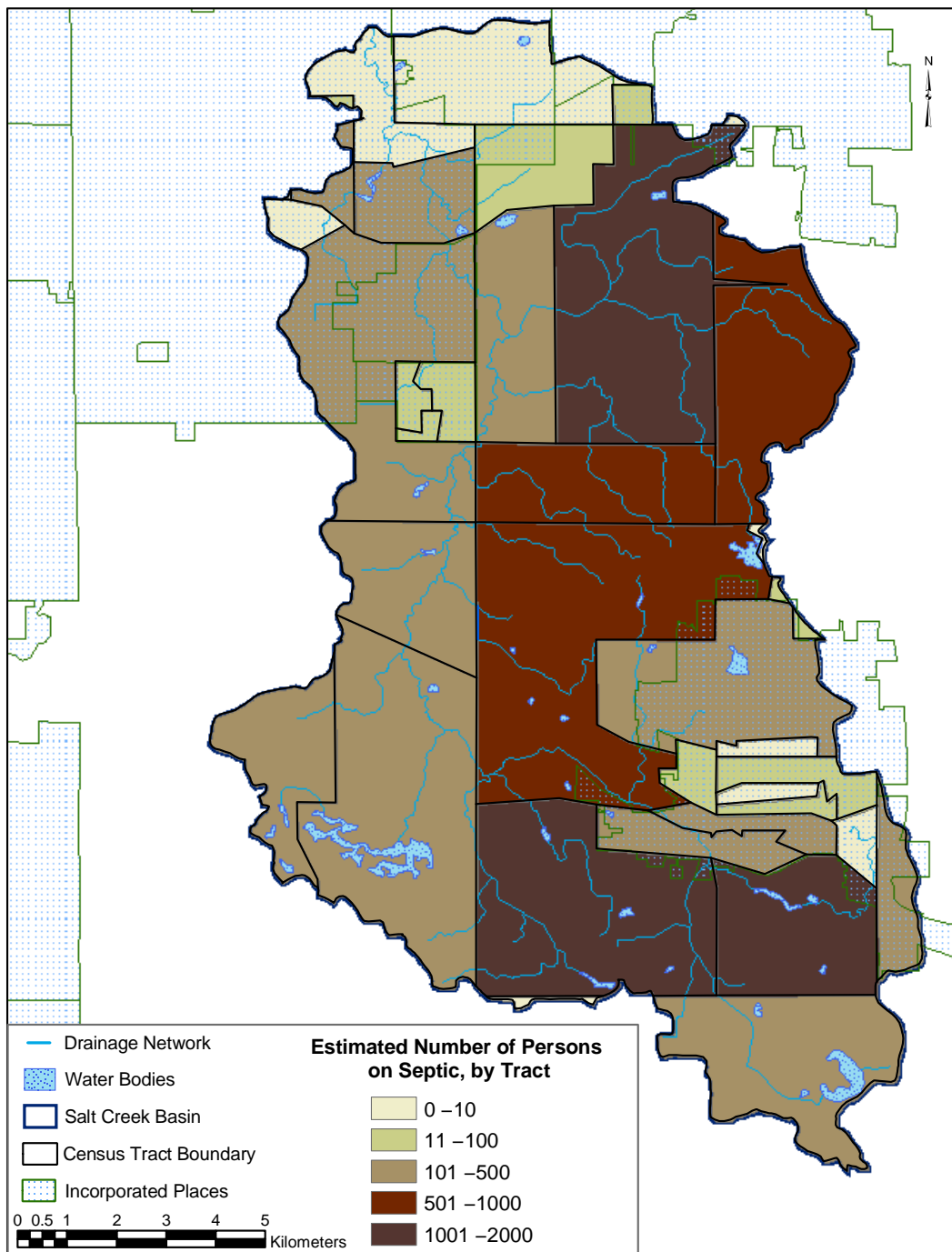Figure 3: Number of houses on septic systems in the Salt Creek watershed [U.S. Census Bureau, 1999].

Figure 4: Number of people with septic systems in the Salt Creek watershed [U.S. Census Bureau, 1999].
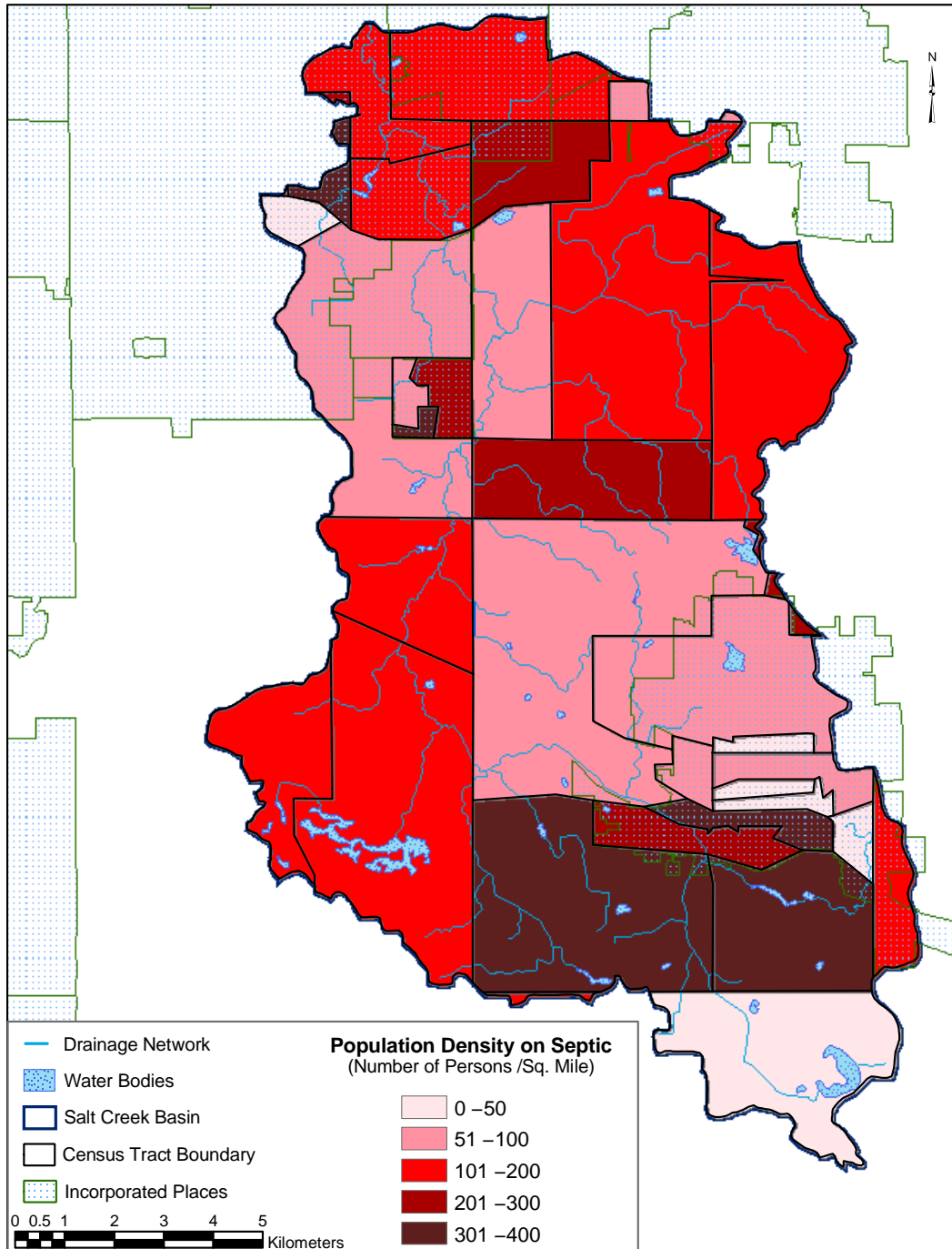
Figure 5: Population density of septic systems in the Salt Creek watershed. Derived from [U.S. Census Bureau, 1999].

Table 12: Number of people on septic systems and number of failed septic systems in the subwatersheds. Derived from [U.S. Census Bureau, 1999, NESC, 2001].

Subwatersheds	Estimated People with Septics (number)	Estimated People with Failed Septics (number)
Upper Salt Creek	237	3.1
Valparaiso	246	3.2
Middle Salt Creek	252	3.3
Damon Run	84	1.1
Lower Salt Creek	203	2.6

The NSFC surveyed local and state public health agencies across the country in the early 1990s regarding the status of on-site systems [NESC, 2001]. Unfortunately, a failure rate for Porter County was not available. We used instead the failure rate published for LaPorte County (1.3 %). The LaPorte County rate is indicative of failure rates for the counties in the region that responded to the survey. This septic failure rate was also confirmed by the Porter County Health Department's numbers of repair permits issued in Porter County in 2002 and an estimation of septic failure [Letta, 2003]. The failure rate was used in conjunction with the number of people on septic systems to calculate the number of failed septics in each subwatershed (Table 12). The subwatershed loading rates were calculated with a typical effluent discharge rate of 70 gallons/person/day and the average *E. coli* concentration of sewage when it reaches the stream [Horsley and Whitten, 1996]. The *E. coli* concentration of septic sewage at the point when it reaches the stream was not available, so the *E. coli* concentration in raw sewage was used (8.8×10^6CFU/100mL) [Turner et al., 1997]. This value is most likely an overestimation because the *E. coli* population would probably be reduced from detrimental environmental conditions as it moved from the septic tank to the stream. However, there is evidence that *E. coli* can survive and even reproduce in the natural environment given the right environmental conditions [Turco, 2002]. In addition, the probable underestimation of the septic failure rate may be balanced from this overestimation in *E. coli* concentration. Estimated loading rates from failed septics are presented in Table 6A .

3.7 Illicit Discharges

Illicit discharges usually involve an illegal or improper connection to a storm drains or a "straight pipe" to receiving waters. Illicit discharge of sewage can derive from domestic and industrial sources. Such sources are difficult to identify; often owners are not even aware of the problem. Programs to identify illicit connections can be resource intensive. However, illicit discharges can be a major source of fecal loading in a watershed. Information about existing or potential illicit discharges in the Salt Creek watershed is not available. Keith Letta of the Porter County Health Department believes that illicit discharges are not a significant problem in the watershed [Letta, 2003]. Due to lack of information, potential loading rates from this source category were not estimated.

4 Uncertainty in Loading Estimates

The objective of the source assessment is to estimate the type, magnitude, and location of *E. coli* loading to Salt Creek. These estimates are required in order to begin modeling the effects of the combined loading on water quality in the stream. It is clear that substantial uncertainty exists with respect to some of the loading from the identified potential sources. For instance, WHPA was unable to identify any illicit discharges of residential sewage to streams or ditches. While we are not able to identify the number or location of illicit discharges of untreated sewage, based on our conversations with watershed managers, health department officials, and soil scientists throughout the state, it is unlikely that none exist in the watershed [WHPA, 2002]. Similarly, there is uncertainty in the density of wildlife and urban loading rates.

In effect, this report documents the steps WHPA has taken to estimate the distribution and magnitude of *E. coli* sources, but we acknowledge the inherent uncertainty in these estimates. The estimates presented here are merely a starting point for the modeling process. Through the modeling process we will attempt to gauge the relative importance of uncertainties in loading estimates and ultimately gauge the importance of uncertainties on load allocations.

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A   Appendix

Table 1A. Monthly accumulation values (MON-ACCUM) and the build-up limit (MON-SQOLIM) for Cropland in the Salt Creek subwatersheds.

CROPLAND		
January		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	(count/acre)
Upper Salt Creek Basin	1.31E+08	2.35E+08
Valparaiso Basin	1.31E+08	2.35E+08
Middle Salt Creek Basin	1.31E+08	2.35E+08
Lower Salt Creek Basin	1.31E+08	2.35E+08
Damon Run Basin	1.31E+08	2.35E+08
February		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	(count/acre)
Upper Salt Creek Basin	1.31E+08	2.35E+08
Valparaiso Basin	1.31E+08	2.35E+08
Middle Salt Creek Basin	1.31E+08	2.35E+08
Lower Salt Creek Basin	1.31E+08	2.35E+08
Damon Run Basin	1.31E+08	2.35E+08
March		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	(count/acre)
Upper Salt Creek Basin	1.79E+08	3.21E+08
Middle Salt Creek Basin	1.31E+08	2.35E+08
Lower Salt Creek Basin	1.96E+08	3.53E+08
Valparaiso Basin	1.43E+08	2.57E+08
Damon Run Basin	6.74E+08	1.21E+09
April		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	(count/acre)
Upper Salt Creek Basin	1.80E+08	2.70E+08
Middle Salt Creek Basin	1.31E+08	1.96E+08
Lower Salt Creek Basin	1.98E+08	2.97E+08
Valparaiso Basin	1.43E+08	2.15E+08
Damon Run Basin	6.92E+08	1.04E+09
May		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	(count/acre)
Upper Salt Creek Basin	1.79E+08	2.68E+08
Middle Salt Creek Basin	1.31E+08	1.96E+08
Lower Salt Creek Basin	1.96E+08	2.94E+08
Valparaiso Basin	1.43E+08	2.14E+08
Damon Run Basin	6.74E+08	1.01E+09
June		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	(count/acre)
Upper Salt Creek Basin	1.31E+08	1.96E+08
Middle Salt Creek Basin	1.31E+08	1.96E+08
Lower Salt Creek Basin	1.31E+08	1.96E+08
Valparaiso Basin	1.31E+08	1.96E+08
Damon Run Basin	1.31E+08	1.96E+08

Table 1A. Monthly accumulation values (MON-ACCUM) and the build-up limit (MON-SQOLIM) for Cropland in the Salt Creek subwatersheds – continued.

CROPLAND		
July		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	1.31E+08	1.96E+08
Middle Salt Creek Basin	1.31E+08	1.96E+08
Lower Salt Creek Basin	1.31E+08	1.96E+08
Valparaiso Basin	1.31E+08	1.96E+08
Damon Run Basin	1.31E+08	1.96E+08
August		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	1.31E+08	1.96E+08
Middle Salt Creek Basin	1.31E+08	1.96E+08
Lower Salt Creek Basin	1.31E+08	1.96E+08
Valparaiso Basin	1.31E+08	1.96E+08
Damon Run Basin	1.31E+08	1.96E+08
September		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	1.31E+08	1.96E+08
Middle Salt Creek Basin	1.31E+08	1.96E+08
Lower Salt Creek Basin	1.31E+08	1.96E+08
Valparaiso Basin	1.31E+08	1.96E+08
Damon Run Basin	1.31E+08	1.96E+08
October		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	1.79E+08	3.21E+08
Middle Salt Creek Basin	1.31E+08	2.35E+08
Lower Salt Creek Basin	1.96E+08	3.53E+08
Valparaiso Basin	1.43E+08	2.57E+08
Damon Run Basin	6.74E+08	1.21E+09
November		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	1.80E+08	3.24E+08
Middle Salt Creek Basin	1.31E+08	2.35E+08
Lower Salt Creek Basin	1.98E+08	3.56E+08
Valparaiso Basin	1.43E+08	2.58E+08
Damon Run Basin	6.92E+08	1.24E+09
December		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	1.31E+08	2.35E+08
Middle Salt Creek Basin	1.31E+08	2.35E+08
Lower Salt Creek Basin	1.31E+08	2.35E+08
Valparaiso Basin	1.31E+08	2.35E+08
Damon Run Basin	1.31E+08	2.35E+08

Table 2A. Monthly accumulation values (MON-ACCUM) and the build-up limit (MON-SQOLIM) for Pastureland in the Salt Creek subwatersheds.

PASTURELAND		
January		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	4.43E+08	7.98E+08
Valparaiso Basin	2.58E+08	4.64E+08
Middle Salt Creek Basin	6.47E+08	1.16E+09
Lower Salt Creek Basin	2.63E+08	4.74E+08
Damon Run Basin	7.81E+08	1.41E+09
February		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	4.43E+08	7.98E+08
Valparaiso Basin	2.58E+08	4.64E+08
Middle Salt Creek Basin	6.47E+08	1.16E+09
Lower Salt Creek Basin	2.63E+08	4.74E+08
Damon Run Basin	7.81E+08	1.41E+09
March		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	4.43E+08	7.98E+08
Valparaiso Basin	2.58E+08	4.64E+08
Middle Salt Creek Basin	6.47E+08	1.16E+09
Lower Salt Creek Basin	2.63E+08	4.74E+08
Damon Run Basin	7.81E+08	1.41E+09
April		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	4.37E+08	6.55E+08
Valparaiso Basin	2.88E+08	4.32E+08
Middle Salt Creek Basin	6.54E+08	9.81E+08
Lower Salt Creek Basin	2.63E+08	3.95E+08
Damon Run Basin	8.15E+08	1.22E+09
May		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	4.37E+08	6.55E+08
Valparaiso Basin	2.87E+08	4.31E+08
Middle Salt Creek Basin	6.53E+08	9.80E+08
Lower Salt Creek Basin	2.63E+08	3.95E+08
Damon Run Basin	8.14E+08	1.22E+09
June		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	4.31E+08	6.46E+08
Valparaiso Basin	2.58E+08	3.86E+08
Middle Salt Creek Basin	6.29E+08	9.44E+08
Lower Salt Creek Basin	2.58E+08	3.87E+08
Damon Run Basin	7.63E+08	1.14E+09

Table 2A. Monthly accumulation values (MON-ACCUM) and the build-up limit (MON-SQOLIM) for Pastureland in the Salt Creek subwatersheds – continued.

PASTURELAND		
July		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	4.31E+08	6.46E+08
Valparaiso Basin	2.58E+08	3.86E+08
Middle Salt Creek Basin	6.29E+08	9.44E+08
Lower Salt Creek Basin	2.58E+08	3.87E+08
Damon Run Basin	7.63E+08	1.14E+09
August		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	4.31E+08	6.46E+08
Valparaiso Basin	2.58E+08	3.86E+08
Middle Salt Creek Basin	6.29E+08	9.44E+08
Lower Salt Creek Basin	2.58E+08	3.87E+08
Damon Run Basin	7.63E+08	1.14E+09
September		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	4.31E+08	6.46E+08
Valparaiso Basin	2.58E+08	3.86E+08
Middle Salt Creek Basin	6.29E+08	9.44E+08
Lower Salt Creek Basin	2.58E+08	3.87E+08
Damon Run Basin	7.63E+08	1.14E+09
October		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	4.37E+08	7.86E+08
Valparaiso Basin	2.87E+08	5.17E+08
Middle Salt Creek Basin	6.53E+08	1.18E+09
Lower Salt Creek Basin	2.63E+08	4.74E+08
Damon Run Basin	8.14E+08	1.46E+09
November		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	4.37E+08	7.86E+08
Valparaiso Basin	2.88E+08	5.19E+08
Middle Salt Creek Basin	6.54E+08	1.18E+09
Lower Salt Creek Basin	2.63E+08	4.74E+08
Damon Run Basin	8.15E+08	1.47E+09
December		
	MON-ACCUM	**MON-SQOLIM**
	(count/acre/day)	**(count/acre)**
Upper Salt Creek Basin	4.43E+08	7.98E+08
Valparaiso Basin	2.58E+08	4.64E+08
Middle Salt Creek Basin	6.47E+08	1.16E+09
Lower Salt Creek Basin	2.63E+08	4.74E+08
Damon Run Basin	7.81E+08	1.41E+09

Table 3A. *E. coli* loading rates of from cattle with direct stream access in the Salt Creek subwatersheds.

CATTLE AS A POINT SOURCE			EC Loading Rate	Waste Flow
January	**# grazing beef cattle**	**# cattle in streams**	**(count/hr)**	**(cfs)**
Upper Salt Creek Basin	46	0	0.00E+00	0.00E+00
Valparaiso Basin	0	0	0.00E+00	0.00E+00
Middle Salt Creek Basin	101	0	0.00E+00	0.00E+00
Lower Salt Creek Basin	11	0	0.00E+00	0.00E+00
Damon Run Basin	57	0	0.00E+00	0.00E+00
			EC Loading Rate	**Waste Flow**
February	**# grazing beef cattle**	**# cattle in streams**	**(count/hr)**	**(cfs)**
Upper Salt Creek Basin	46	0	0.00E+00	0.00E+00
Valparaiso Basin	0	0	0.00E+00	0.00E+00
Middle Salt Creek Basin	101	0	0.00E+00	0.00E+00
Lower Salt Creek Basin	11	0	0.00E+00	0.00E+00
Damon Run Basin	57	0	0.00E+00	0.00E+00
			EC Loading Rate	**Waste Flow**
March	**# grazing beef cattle**	**# cattle in streams**	**(count/hr)**	**(cfs)**
Upper Salt Creek Basin	46	0	0.00E+00	0.00E+00
Valparaiso Basin	0	0	0.00E+00	0.00E+00
Middle Salt Creek Basin	101	0	0.00E+00	0.00E+00
Lower Salt Creek Basin	11	0	0.00E+00	0.00E+00
Damon Run Basin	57	0	0.00E+00	0.00E+00
			EC Loading Rate	**Waste Flow**
April	**# grazing beef cattle**	**# cattle in streams**	**(count/hr)**	**(cfs)**
Upper Salt Creek Basin	46	1	1.20E+09	1.17E-05
Valparaiso Basin	0	0	0.00E+00	0.00E+00
Middle Salt Creek Basin	101	3	2.65E+09	2.60E-05
Lower Salt Creek Basin	11	0	2.76E+08	2.71E-06
Damon Run Basin	57	2	1.49E+09	1.46E-05
			EC Loading Rate	**Waste Flow**
May	**# grazing beef cattle**	**# cattle in streams**	**(count/hr)**	**(cfs)**
Upper Salt Creek Basin	46	1	1.20E+09	1.17E-05
Valparaiso Basin	0	0	0.00E+00	0.00E+00
Middle Salt Creek Basin	101	3	2.65E+09	2.60E-05
Lower Salt Creek Basin	11	0	2.76E+08	2.71E-06
Damon Run Basin	57	2	1.49E+09	1.46E-05
			EC Loading Rate	**Waste Flow**
June	**# grazing beef cattle**	**# cattle in streams**	**(count/hr)**	**(cfs)**
Upper Salt Creek Basin	46	1	1.20E+09	1.17E-05
Valparaiso Basin	0	0	0.00E+00	0.00E+00
Middle Salt Creek Basin	101	3	2.65E+09	2.60E-05
Lower Salt Creek Basin	11	0	2.76E+08	2.71E-06
Damon Run Basin	57	2	1.49E+09	1.46E-05

Table 3A. *E. coli* loading rates of from cattle with direct stream access in the Salt Creek subwatersheds – continued.

CATTLE AS A POINT SOURCE			EC Loading Rate	Waste Flow
July	# grazing beef cattle	# cattle in streams	(count/hr)	(cfs)
Upper Salt Creek Basin	46	1	1.20E+09	1.17E-05
Valparaiso Basin	0	0	0.00E+00	0.00E+00
Middle Salt Creek Basin	101	3	2.65E+09	2.60E-05
Lower Salt Creek Basin	11	0	2.76E+08	2.71E-06
Damon Run Basin	57	2	1.49E+09	1.46E-05
			EC Loading Rate	Waste Flow
August	# grazing beef cattle	# cattle in streams	(count/hr)	(cfs)
Upper Salt Creek Basin	46	1	1.20E+09	1.17E-05
Valparaiso Basin	0	0	0.00E+00	0.00E+00
Middle Salt Creek Basin	101	3	2.65E+09	2.60E-05
Lower Salt Creek Basin	11	0	2.76E+08	2.71E-06
Damon Run Basin	57	2	1.49E+09	1.46E-05
			EC Loading Rate	Waste Flow
September	# grazing beef cattle	# cattle in streams	(count/hr)	(cfs)
Upper Salt Creek Basin	46	1	1.20E+09	1.17E-05
Valparaiso Basin	0	0	0.00E+00	0.00E+00
Middle Salt Creek Basin	101	3	2.65E+09	2.60E-05
Lower Salt Creek Basin	11	0	2.76E+08	2.71E-06
Damon Run Basin	57	2	1.49E+09	1.46E-05
			EC Loading Rate	Waste Flow
October	# grazing beef cattle	# cattle in streams	(count/hr)	(cfs)
Upper Salt Creek Basin	46	1	1.20E+09	1.17E-05
Valparaiso Basin	0	0	0.00E+00	0.00E+00
Middle Salt Creek Basin	101	3	2.65E+09	2.60E-05
Lower Salt Creek Basin	11	0	2.76E+08	2.71E-06
Damon Run Basin	57	2	1.49E+09	1.46E-05
			EC Loading Rate	Waste Flow
November	# grazing beef cattle	# cattle in streams	(count/hr)	(cfs)
Upper Salt Creek Basin	46	1	1.20E+09	1.17E-05
Valparaiso Basin	0	0	0.00E+00	0.00E+00
Middle Salt Creek Basin	101	3	2.65E+09	2.60E-05
Lower Salt Creek Basin	11	0	2.76E+08	2.71E-06
Damon Run Basin	57	2	1.49E+09	1.46E-05
			EC Loading Rate	Waste Flow
December	# grazing beef cattle	# cattle in streams	(count/hr)	(cfs)
Upper Salt Creek Basin	46	0	0.00E+00	0.00E+00
Valparaiso Basin	0	0	0.00E+00	0.00E+00
Middle Salt Creek Basin	101	0	0.00E+00	0.00E+00
Lower Salt Creek Basin	11	0	0.00E+00	0.00E+00
Damon Run Basin	57	0	0.00E+00	0.00E+00

Table 4A. Monthly accumulation values (MON-ACCUM) and the build-up limit (MON-SQOLIM) for Forest in the Salt Creek subwatersheds.

FOREST		
All Months		
	ACQOP	SQOLIM
	(count/acre/day)	(count/acre)
Upper Salt Creek Basin	1.30E+08	2.33E+08
Middle Salt Creek Basin	1.30E+08	2.33E+08
Lower Salt Creek Basin	1.30E+08	2.33E+08
Valparaiso Basin	1.30E+08	2.33E+08
Damon Run Basin	1.30E+08	2.33E+08

Table 5A. Monthly accumulation values (MON-ACCUM) and the build-up limit (MON-SQOLIM) for Built-up in the Salt Creek subwatersheds.

BUILT-UP		
All Months		
	ACQOP	SQOLIM
	(count/acre/day)	(count/acre)
Upper Salt Creek Basin	2.00E+05	3.59E+05
Valparaiso Basin	2.00E+05	3.59E+05
Middle Salt Creek Basin	2.00E+05	3.59E+05
Lower Salt Creek Basin	2.00E+05	3.59E+05
Damon Run Basin	2.00E+05	3.59E+05

Table 6A. Flow rates from failed septic systems in the Salt Creek subwatersheds.

SEPTICS AS A POINT SOURCE						
Subwatershed	# people on septics	Tot. # people failed septics	Septic flow (gal/day)	Septic flow (mL/hr)	EC rate (count/hr)	Septic flow (cfs)
Upper Salt Creek Basin	236.7	3.1	215	33,973	3.40E+06	3.34E-04
Valparaiso Basin	246.1	3.2	224	35,318	3.53E+06	3.47E-04
Middle Salt Creek Basin	251.7	3.3	229	36,120	3.61E+06	3.55E-04
Lower Salt Creek Basin	84.2	1.1	77	12,077	1.21E+06	1.19E-04
Damon Run Basin	203.3	2.6	185	29,179	2.92E+06	2.87E-04